Microbiology Introduction

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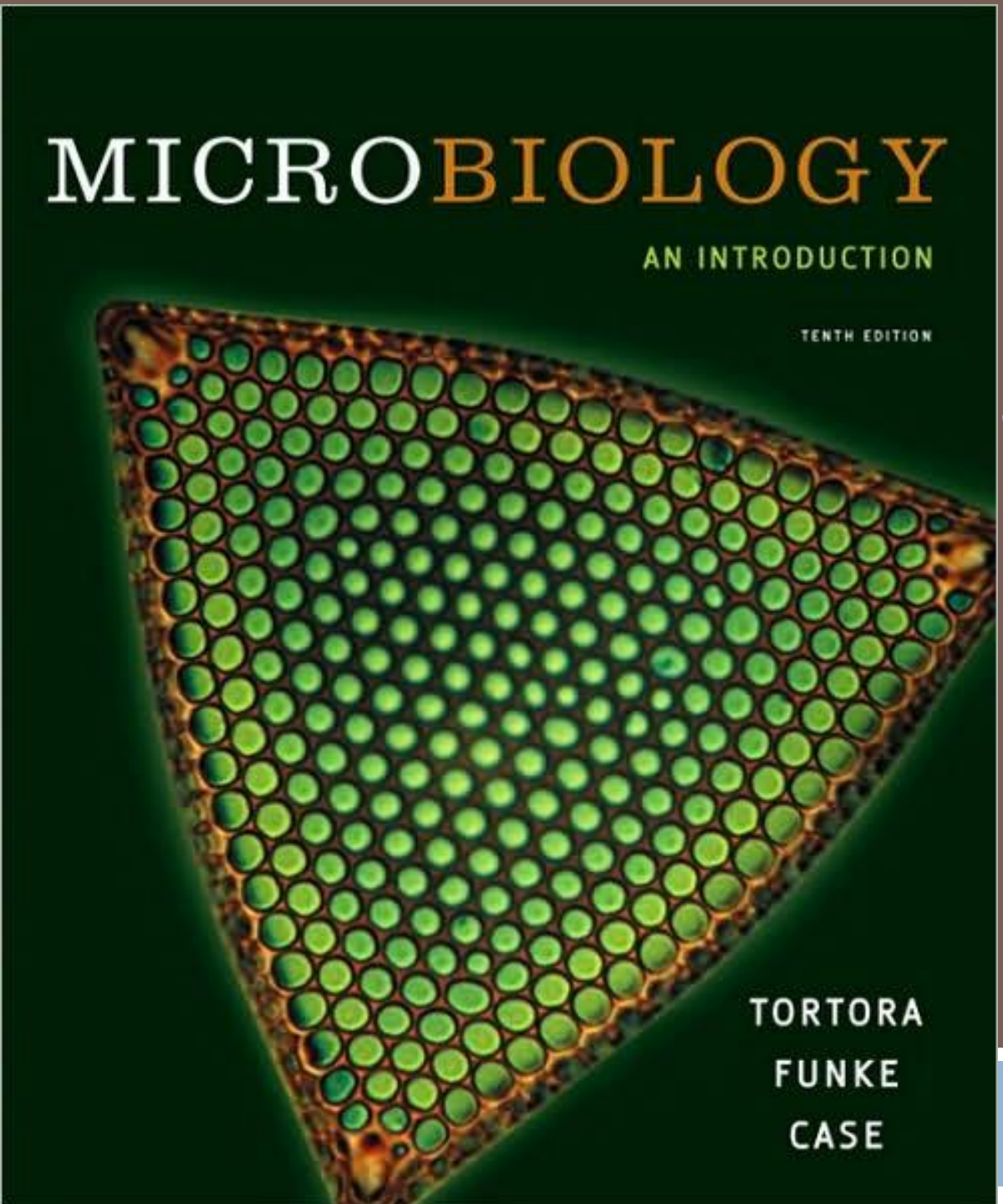
(1st) semester

1st lecture



Welcome to Micro-biology

Microbiology:

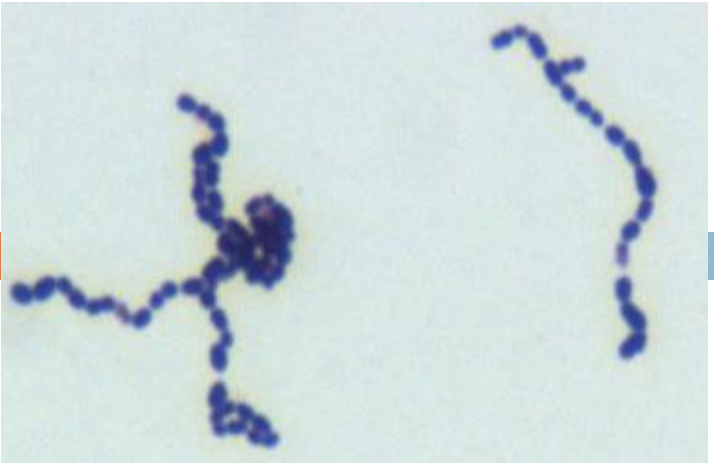
The study of microorganisms.

Microorganisms: Small living organisms that generally can not be seen with the naked eye.

Microbes which is visible only with a microscope.

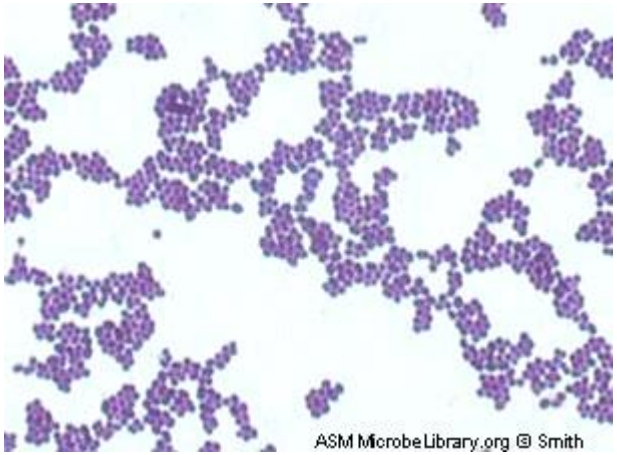
Naming and Classifying Microorganisms

- Carolus Linnaeus established the system of **scientific nomenclature** in 1739.
- Each organism has two names → **Binomial nomenclature**: ***Genus*** + ***specific epithet*** *(species)*
- *Italicized* (or <u>underlined</u>), genus capitalized, "latinized", used worldwide.
- May be descriptive or honor a scientist.



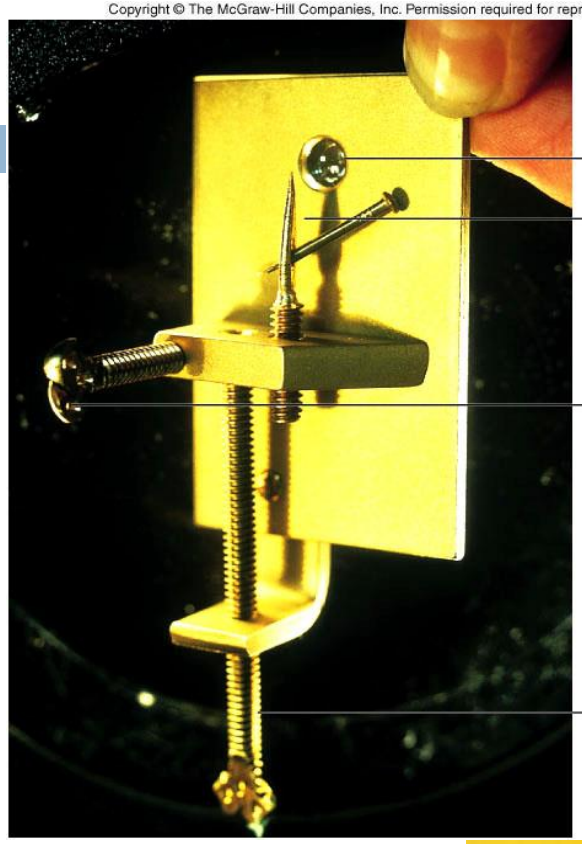
Examples

- *Staphylococcus aureus (S. aureus)*
- *Escherichia coli (E. coli)*
- *Streptococcus pneumoniae (S. pneumoniae)*



Microbiology History
The Beginnings

- Ancestors of bacteria were the first life on Earth
- 1665: Cell theory – Robert Hooke



Compare to Fig 1.2

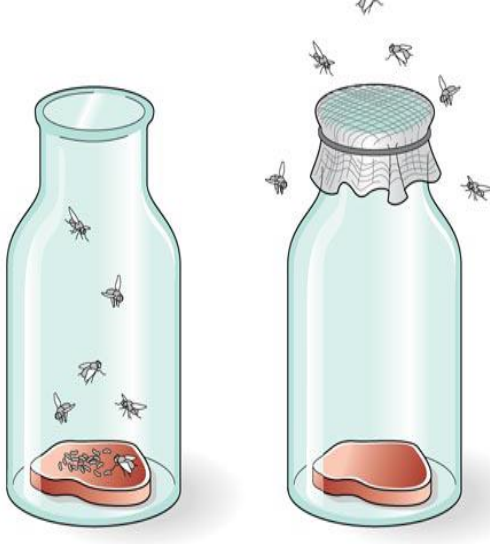
- 1673: First microbes observed – Anton van Leeuwenhoek

The Transition Period: Debate over Spontaneous Generation

- **Aristotles's doctrine of spontaneous generation.** Hypothesis that living organisms arise from nonliving matter; a "vital force" forms life
- **Biogenesis**: Hypothesis that the living organisms arise from preexisting life

1668:Francesco Redi

- the beginnings of experimental science
- filled 6 jars with decaying meat



Conditions	**Results**
Three jars covered with fine net	No maggots
Three open jars	Maggots appeared
From where did the maggots come? What was the purpose of the sealed jars? *Spontaneous generation or biogenesis?*	

1745: John Needham

Objections

Put boiled nutrient broth into covered flasks

Conditions	**Results**
Nutrient broth heated, then placed in sealed flask	Microbial growth
From where did the microbes come? *Spontaneous generation or biogenesis?*	

1765: Lazzaro Spallanzani

- boiled nutrient solutions in flasks

Conditions	**Results**
Nutrient broth placed in flask, heated, then sealed	No microbial growth
Spontaneous generation or biogenesis?	

The Golden Age of Microbiology(1857-1914)

Microbiology established as a science

Louis Pasteur

- Spontaneous generation disproved
- Wine fermentation (yeasts and bacteria)
- Pasteurization

Pre-Pasteur:

Ignaz Semmelweis (1840s) – hand disinfection and puerperal fever

Based on Pateur's and Semmelweis' findings:

Joseph Lister (1860s) –antiseptic surgery (phenol)

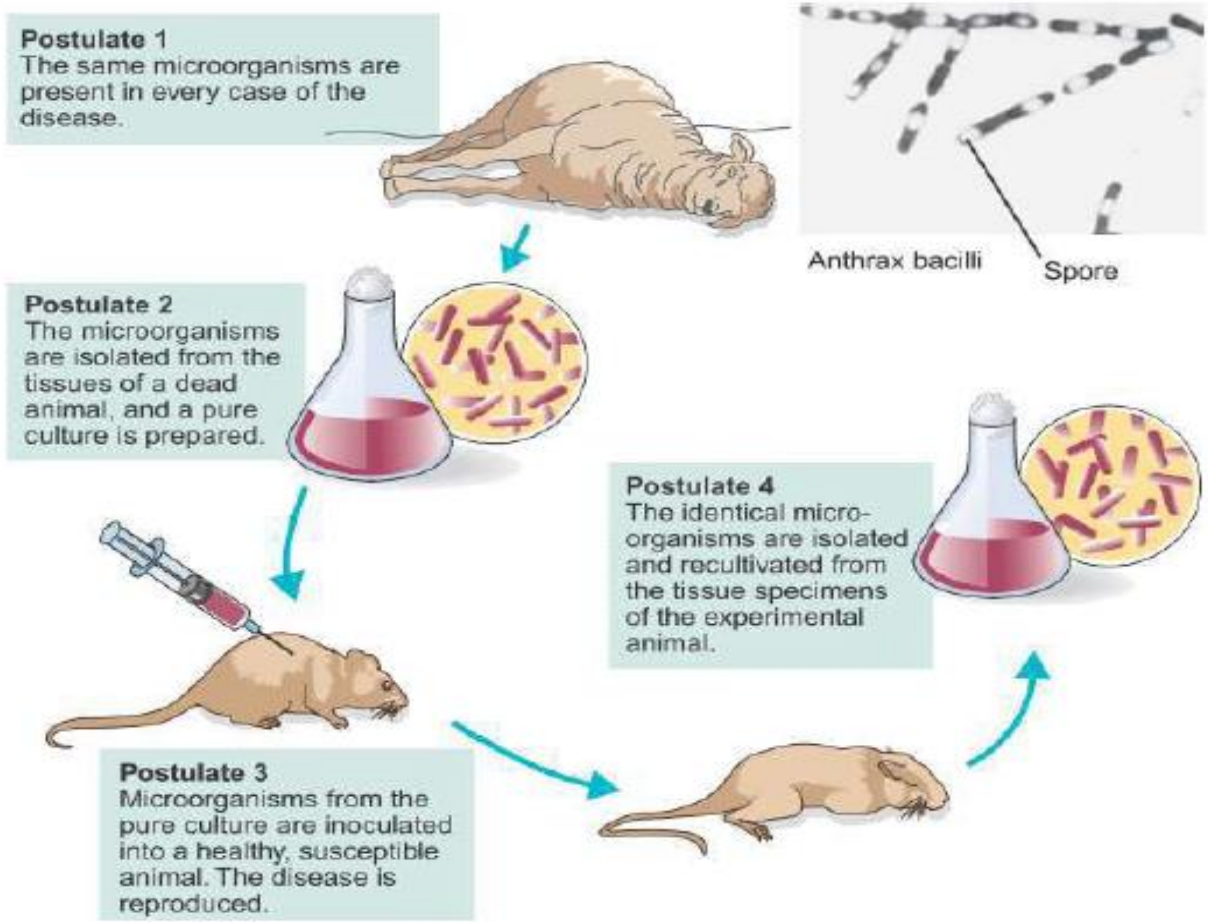
Robert Koch

- Work on anthrax proves the **germ theory of disease**
- Procedures become Koch's postulates
- Development of pure culture technique
- Nobel Prize in 1905

THE GERM THEORY OF DISEASE

- **Germ Theory:** One microbe causes one specific disease.
- Proved that *Bacillus anthracis* causes anthrax in cattle.
- Later identified bacterium that causes tuberculosis.

KOCH'S POSTULATES



KOCH'S POSTULATES

- 1-The microorganism must be present in every instance of the disease and absent from healthy individuals.
- 2- The microorganism must be capable of being isolated and grown in pure culture.
- 3- When the microorganism is inoculated into a healthy host, the same disease condition must result.
- 4-The same microorganism must be re-isolated from the experimentally infected host.

- Using his postulates, Koch identified causative agents for tuberculosis, diphtheria, human cholera, typhoid, tetanus, and other diseases. The postulates are still applied today, although there are some limitations.

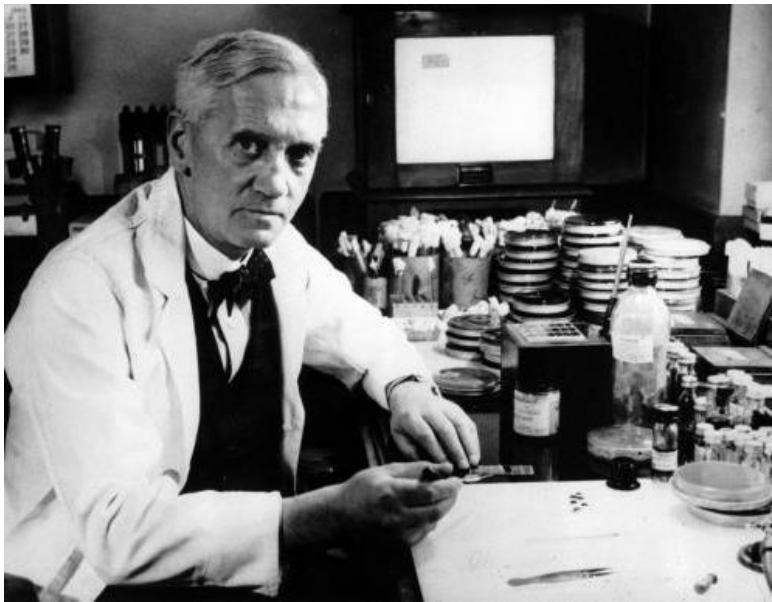
Before the Golden Age Period:
The Birth of Vaccination

- Jenner and smallpox vaccination (1796)

- ~ 100 years later: Pasteur shows how vaccinations work. (Creation of avirulent strains of bacteria during extended laboratory cultivation)

The Birth of Modern Chemotherapy

- 1910: Paul Ehrlich developed a synthetic arsenic drug, salvarsan, to treat syphilis
- 1930s: Synthesis of sulfonamides
- 1928: Alexander Fleming and the discovery of the **first antibiotic**



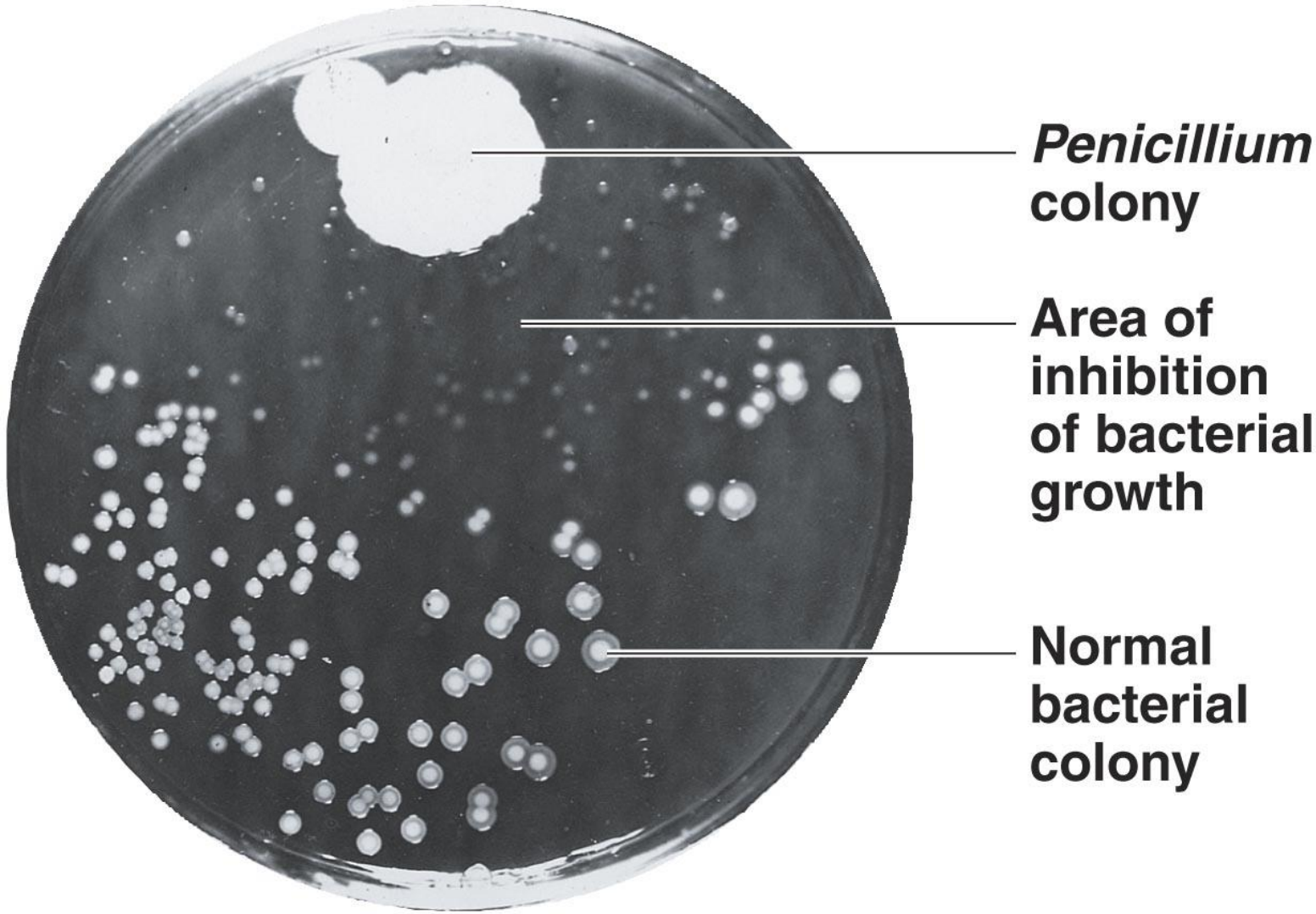


Fig 1.5

Penicillin purification and clinical trials not until 1940s

Modern Developments in Microbiology

- Bacteriology – Mycology – Parasitology – Virology – Immunology

- Microbial genetics and molecular biology lead to **Recombinant DNA Technology** (genetic engineering). Prokaryotic model system: *E. coli*

MODERN DEVELOPMENTS IN MICROBIOLOGY

- Bacteriology is the study of bacteria.
- Mycology is the study of fungi.
- Parasitology is the study of protozoa and parasitic worms.
- Immunology is the study of immunity. Vaccines and interferons are being investigated to prevent and cure viral diseases.

MODERN DEVELOPMENTS IN MICROBIOLOGY

- Virology is the study of viruses.
- Recombinant DNA technology or genetic engineering involves microbial genetics and molecular biology.
- Recent advances in genomics, the study of an organism's genes, have provided new tools for classifying microorganisms.

Selected Nobel Prizes for Microbiology Research

1901 von Behring	Diphtheria antitoxin
1902 Ross	Malaria transmission
1905 Koch	TB bacterium
1908 Metchnikoff	Phagocytes
1945 Fleming, Chain, Florey	Penicillin
1952 Waksman	Streptomycin
1969 Delbrück, Hershey, Luria	Viral replication
1987 Tonegawa	Antibody genetics
1997 Prusiner	Prions
2005 Marshall & Warren	*H. pylori* & ulcers

Types of Microorganisms

- Bacteria
- Archaea
- Fungi
- Protozoa
- Algae
- Viruses
- Multicellular animal parasites
- Prions and viroids

Microorganisms divided to **Acellular** & **Cellular**.

I. Acellular "without a cell": (**viruses, prions and viroids**

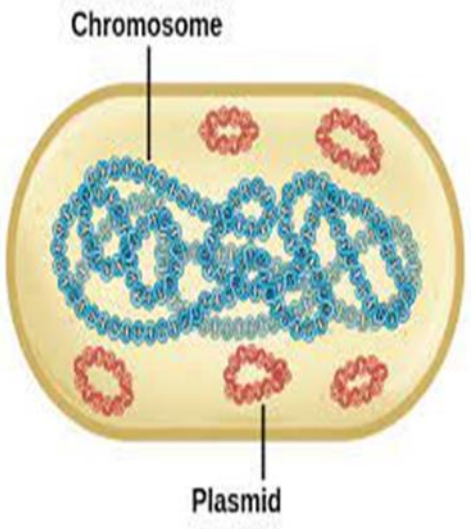
II. Cellular which includes:

1. Prokaryotic ("before nucleus") – these guys are cells, but they have no internal membrane bound structures (no membrane-bound nucleus or membrane-bound organelles); includes only the bacteria.

2. Eukaryotic ("true nucleus") – do have internal membrane bound structures (membrane bound nucleus and membrane-bound organelles); includes organisms such as protozoans, fungi, algae, animals, plants.

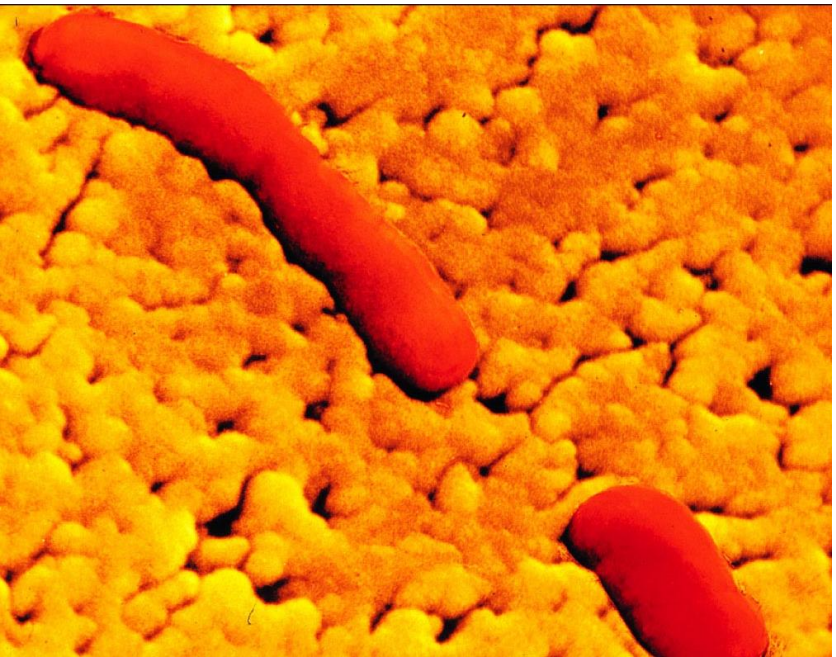
In prokaryotes the **bacterial genome**, or **chromosome**, is a single, circular molecule of double-stranded DNA, lacking a nuclear membrane (Smaller circular DNA molecules called **Plasmids** may also be present in bacteria)

Whereas **the eukaryotic cell** has a true nucleus with multiple chromosomes surrounded by a nuclear membrane. Bacteria comprise the vast majority of human pathogens.



Bacterium / Bacteria

- Prokaryotic
- Peptidoglycan cell wall
- Reproduction by binary fission

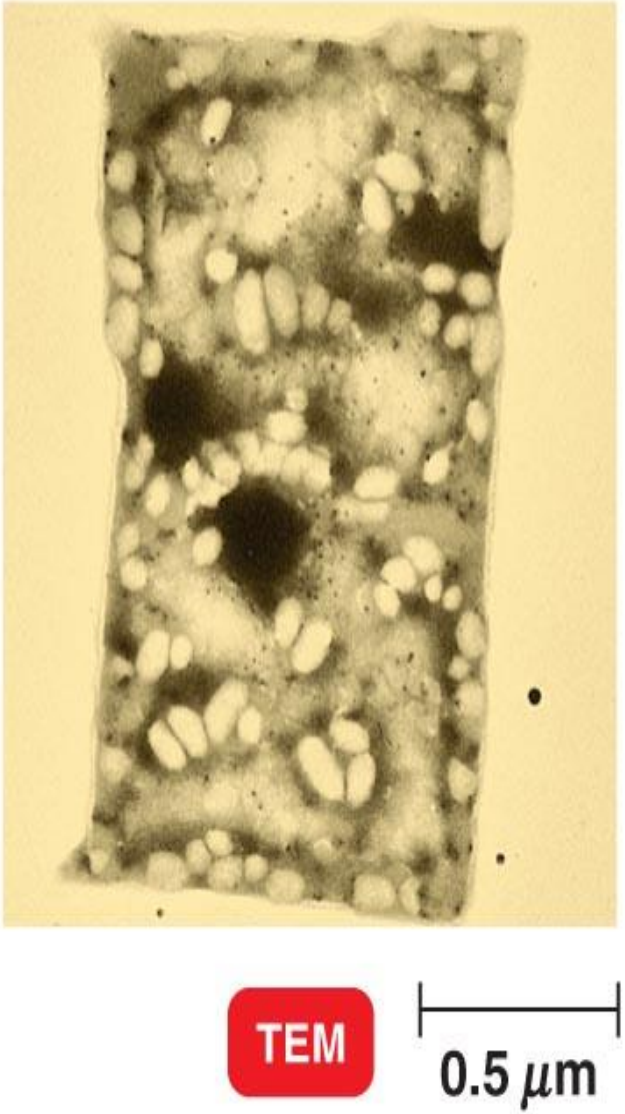


Gain energy from use of

- organic chemicals
- inorganic chemicals or
- photosynthesis

Archaea

- Prokaryotic
- No peptidoglycan
- Live in extreme environments
- Include
  - Methanogens
  - Extreme halophiles
  - Extreme thermophiles



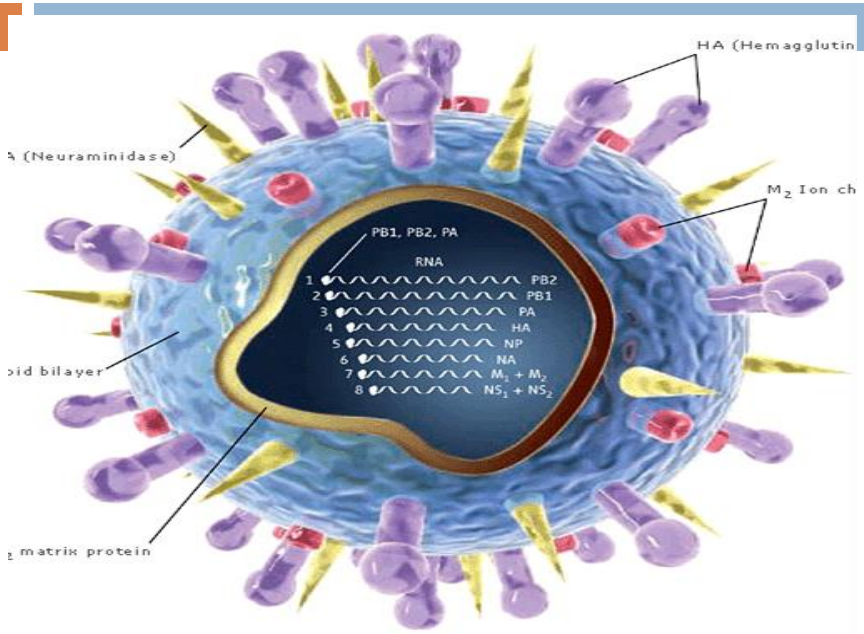
Fungus/Fungi

- Use organic chemicals for energy.
- **Molds** and mushrooms are multicellular consisting of masses of **mycelia**, which are composed of filaments called **hyphae**.
- **Yeasts** are unicellular.

Protozoan/ Protozoa

- Eukaryotes
- Absorb or ingest organic chemicals
- May be motile via pseudopods, cilia, or flagella

Viruses



- Are acellular
- Have either DNA or RNA in core
- Core is surrounded by a protein coat.
- Coat may be enclosed in a lipid envelope.
- Viruses only replicate within a living host cell.

Multicellular Animal Parasites

- Eukaryotes
- Multicellular animals
- Helminths are parasitic flatworms and round worms
- Microscopic stages in life cycles

Basis of Taxonomy

✓ **Phenetic system** groups organisms based on mutual similarity of phenotypic characteristics. May or may not correctly match evolutionary grouping, e.g. motile v/s non motile bacteria

✓ **Phylogenetic system** groups organisms based on shared evolutionary genetic heritage.

Five kingdom system of biological classification

Based on cellular organization and nutritional patterns:

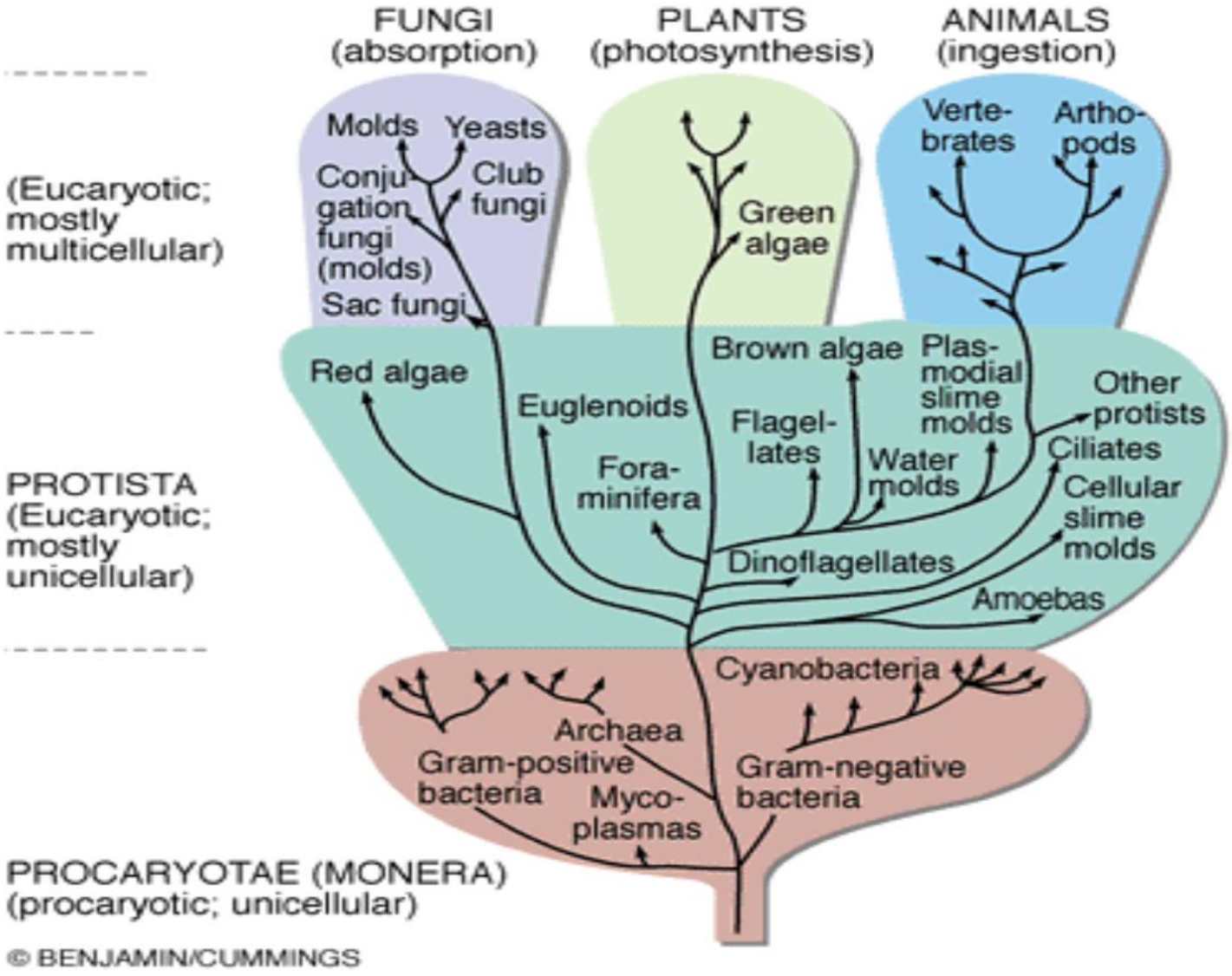
✓ **Procaryotae or Monera** - prokaryotic, unicellular, variable nutrition patterns, lack nucleus and membrane bound organelles – bacteria.

✓ **Protista-** eukaryotic, unicellular or colonial, heterotrophic, lack tissue organization, most have flagella during life – protozoa, slime molds, some algae.

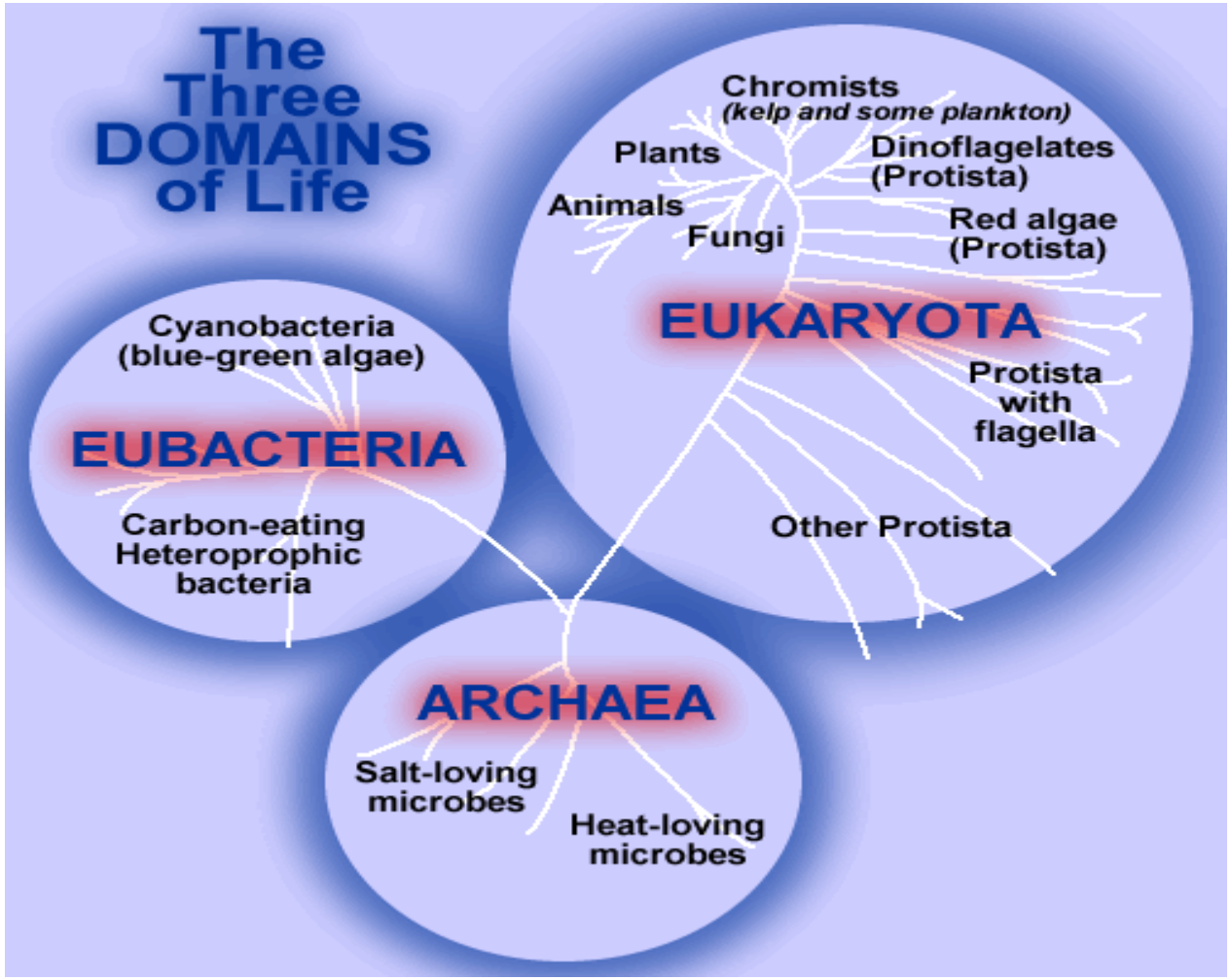
✓ **Myceteae or Fungi** - eukaryotic, unicellular or multicellular, heterotrophic or absorptive – molds, yeasts, mushrooms.

✓ **Plantae** - eukaryotic, multicellular or colonial, autotrophic – plants, some algae, mosses, ferns.

✓ **Animalia -** eukaryotic, multicellular, heterotrophic or ingestive , that ingest food through a mouth or oral cavity – animals



Three Domain Classification



- **Bacteria**
- **Archaea**
- **Eukarya**
  - Protista
  - Fungi
  - Plants
  - Animals

The Three Domains

➢Based on cellular rRNAs sequence primarily, rRNA molecules throughout nature carry out the same function over time. and genetically stable very little

➢Cell wall composition

➢Cell membrane lipid structure

➢Sensitivity to antibiotics.

➢Protein synthesis

This system proposes that a common ancestor cell ("Cenancestor") gave rise to three different cell types, each representing **a domain**.

The Eukarya (Eukaryotes)

- **Eukarya** have eukaryotic cells.
- Contain rRNA that is unique to the Eukarya distinctly different from the rRNA of Archaea and Bacteria.
- Cell membranes composed of unbranched fatty acid chains attached to glycerol by **ester linkages** .
- Not all Eukarya possess cell wall, but those having a cell wall does not contains peptidoglycan.
- Eukarya are resistant to traditional antibacterial antibiotics but are sensitive to most antibiotics that affect eukaryotic cells.

The Bacteria (Eubacteria)

- **Bacteria** are prokaryotic cells.
- Contain rRNA that is unique to the Bacteria distinctly different from the rRNA of Archaea and Eukarya.
- Celll membranes composed of unbranched fatty acid chains attached to glycerol by **ester linkages** cell walls contain peptidoglycan.
- Bacteria are sensitive to traditional antibacterial antibiotics but are resistant to most antibiotics that affect Eukarya.

The Archaea(archaebacteria)

- **Archaea** are prokaryotic cells.
- Contain rRNA that is unique to the Archaea distinctly different from the rRNA of Bacteria and Eukarya.
- Cell membranes composed of branched hydrocarbon chains attached to glycerol by **ether linkages**.
- Cell walls of Archaea does not have peptidoglycan.
- Archaea are not sensitive to some antibiotics that affect the Bacteria, but are sensitive to some antibiotics that affect the Eukarya.

Methods of Identifying Bacteria

✓ Morphological characteristics

✓ Biochemical tests

✓ Serological tests

✓ Phage typing

✓ Sequences of amino acids in proteins

✓ Percentage of G-C pairs in the nucleic acid

✓ Number and sizes of DNA fragments produced by restriction enzymes

✓ Sequence of bases in 16S rRNA (Ribotyping)

Microbes help us by

- Decomposing organic waste
- Performing photosynthesis
- Producing ethanol, acetone, vinegar, cheese, bread, . . .
- Producing insulin and many other drugs
- . . .

Microbes harm us by ???????

Beneficial microorganisms

- Helpful bacteria and fungi that are either added or naturally occur in foods.
- Create unique flavors and textures or improve the body's ability to digest foods or fight disease.
- **Example: milk to yogurt.**

The bacteria used in making yoghurt are *Lactobacillus* bacteria.

Milk contains a sugar called lactose. The bacteria are able to break this down to form lactic acid. The lactic acid both lowers the PH of the yoghurt, which helps to preserve it, and denatures milk proteins, which gives the yoghurt its sharp taste.

Beneficial microorganisms

1. Microorganisms play an essential role in carbon and nitrogen cycles.

2. Microorganisms are used in brewing industries to manufacture beer, wine, and in the dairy and food industries to make cheese and yogurt.

3. Microorganisms are used in the manufacture of several industrial solvents and other chemicals.

4. Microorganisms or the toxins they produce can be used as alternatives to chemical insecticides.

5. Microorganisms have been heavily exploited for waste treatment and bioremediation.

Beneficial microorganisms

6. Microorganisms (e.g., bacteria and fungi) are used in the manufacture of antibiotics, steroids, therapeutic enzymes, polysaccharides, vaccines, and many products of recombinant DNA technology.

7. They are used in assays to measure antibiotic concentrations.

8. Microorganism can be used as biological indicators of sterilization.

Decaying process

-Decomposition: is the process by which dead organic substances are broken down into simpler organic or inorganic matter such as carbon dioxide, water, simple sugars and mineral salts.

-Many microbes break down dead and decaying matter and **recycle nutrients** that can be used by other organisms.

-The fungi invade the organic matter in soils first and are then followed by bacteria.

- Many microbes are found in nature and help plants to grow

Oxygen production–Cyanobacteria or 'blue-green algae'produce oxygen in the ocean

Photosynthesis: Algae and some bacteria capture energy from sunlight and convert it to food, forming the basis of the **food chain**.

In the pharmaceutical applications

-Bacteria are used to produce antibiotics, vaccines, and medically-useful enzymes.

-Most antibiotics are made by bacteria that live in soil.
EX:*Actinomycetes* produce tetracyclines, erythromycin, streptomycin,…

-Bacterial products are used in the manufacture of vaccines for immunization against infectious disease.

- Vaccines against diphtheria, typhoid fever and cholera are made from components of the bacteria that cause the respective diseases.

-Some members of the genus produce penicillin, a molecule that is used as an antibiotic, which kills or stops the growth of certain kinds of bacteria

In Biotechnology

-Biotechnology has produced human hormones such as insulin, enzymes such as streptokinase, and human proteins such as interferon and tumor necrosis factor.

-These products are used for the treatment of a various medical conditions and diseases including diabetes, heart attack, tuberculosis and AIDS.

-Another area of biotechnology involves improvement of the qualities of plants through genetic engineering. Genes can be introduced into plants by a bacterium, plants have been genetically engineered so that they are resistant to certain diseases.

-Recent advances in gene splicing allow us to design recombinant microbes that produce important products:

-Human growth hormone (Dwarfism)

-Insulin (Diabetes)

-Blood clotting factor (Hemophilia)

-Recombinant vaccines (Hepatitis A and B vaccines)

-Erythropoietin (Anemia)

-Monoclonal antibodies (Disease diagnosis and prevention).